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CURRENT PROJECT ADMINISTRATION PRACTICES OF OHIO CONTRACTORS

A Thesis

Presented in Partial Fulfillment of the Requirement for the degree of Master of Science in the Graduate School of The Ohio State University

by

Gregory Scott Linville

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The Ohio State University

1992

Master's Examination Committee:

Dr. Richard E. Larew

Dr. Fabian Hadipriono

Dr. E. Earl Whitlatch

Approved by

Richard E. Larew

Adviser
Department of Civil Engineering

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Gregory S. Linville

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The Ohio State University
470 Hitchcock Hall
Columbus, OH 43210-1275

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American competitiveness and economic well being are the catalyst for new relationships between business and academia to collectively work towards integrating Total Quality Management. To initiate development of a closer relationship with the construction industry, the researcher surveyed contractors on their project administration procedures to document current practices, to investigate consistency of data used and methods within, and to identify barriers to improvement. There is agreement among the firms in project administration procedures however there is no consistency within the firms. Barriers to improvements include time and cost of computers, government and regulatory demands, personnel, and fear of change.

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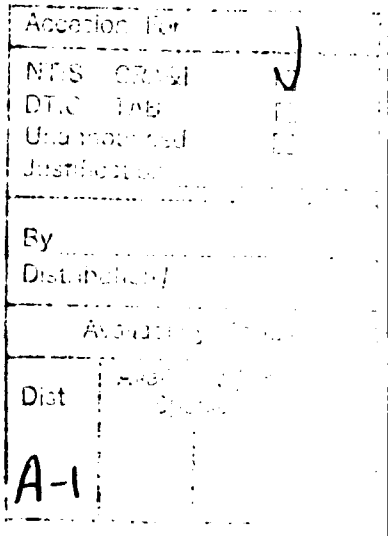

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Department of Civil Engineering

THESIS ABSTRACT

THE OHIO STATE UNIVERSITY
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NAME: Linville, Gregory Scott **QUARTER/YEAR:** Wi/92

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American competitiveness and economic well being are the catalyst for new relationships between business and academia to collectively work towards integrating Total Quality Management. To initiate development of a closer relationship with the construction industry, the researcher surveyed contractors on their project administration procedures to document current practices, to investigate consistency of data used and methods within, and to identify barriers to improvement. There is agreement among the firms in project administration procedures however there is no consistency within the firms. Barriers to improvements include time and cost of computers, government and regulatory demands, personnel, and fear of change.

Richard E. Larew

Adviser's Signature

To man's best friend, especially Lindsay.

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I express forthright appreciation to Dr. Richard E. Larew for his mentoring throughout the research. Appreciation goes to the other members of my advisory committee, Dr. Fabian Hadipriono and Dr. E. Earl Whitlatch for their valuable recommendations. Genuine thanks goes to the construction firms that gave me the opportunity to conduct my survey. I hope this research will be beneficial to them. Earnest appreciation to Sue Kimble for her contribution of professional word processing. Finally, to my parents and family, sincere thanks for your love.

VITA

September 30, 1961.....	Born - Bellefontaine, Ohio
1984.....	B.S., United States Military Academy, West Point, New York
1984.....	Graduate, U.S. Army Engineer Officer Basic Course, Fort Belvoir, Virginia
1988.....	Graduate, U.S. Army Engineer Officer Advanced Couse, Fort Belvoir, Virginia

FIELD OF STUDY

Major Field: Civil Engineering

majoring in Construction Engineering and Management

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CHAPTER I

INTRODUCTION

1.1 Background

American competitiveness and economic well being are current issues that many feel require immediate attention. A recent Harvard Business Review article by James D. Robinson III, et al. calls for top corporations and academia to collectively work toward integrating total quality management (TQM)[1]. TQM can be defined as

> . . . a management philosophy which emphasizes the need to meet customer needs precisely and the importance of doing things right-from the start. It also recognizes that quality improvement will truely be achieved only when it is a goal of all employees, from the boardroom to the assembly line, and becomes part of the fabric and culture of the entire organization.[2]

The article specifically asks academic institutions to: "(L)earn what leading TQM organizations here and abroad are teaching their employees. Encourage company visits by your faculty and develop closer relationships with local TQM companies."[3]

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[1]James D. Robinson III et al., "An Open Letter: TQM on the Campus, "Harvard Business Review, 69 (November - December 1991), p. 94.

[2]Charles F. Hendricks and Arlene Triplett, "TQM: Strategy for '90s Management," Personnel Administrator, 34 (December 1989), 42.

[3]Robinson, p. 95.

The faculty of the Construction Engineering and Management program, Department of Civil Engineering, The Ohio State University, subscribes to the letter's premise and asked this researcher to make contacts with the construction industry. The aim was to determine, if possible, the needs of the construction firms which might be served by the faculty and students at The Ohio State University, and conversely, to identify areas where the university could benefit from the industry's experience. In addition to making contacts with and examining a sector of the construction industry, a second aim was to determine if tasking an engineering graduate student to survey the construction industry is an effective way to learn about the industry.

After evaluating these requirements, the researcher decided to investigate four phases of construction project administration: estimating, scheduling, controlling, and collecting claims.

Estimating is "the process of determining the anticipated cost of materials, labor, and equipment of a proposed project."[4] When estimating, are firms using a computer package such as Timberline[5]? Are they using Walker's Building Estimator's Reference Book or R.S. Means cost estimating manuals?[6] Are they using their own personal experience or their own productivity rates from historical

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[4] Howard M. Chandler and Kornelis Smit, ed., Means Illustrated Construction Dictionary: A New unabridged Edition (Kingston: R.S. Means Company, Inc., 1991), p. 200.

[5]Timberline Software Corporation, P.O. Box 728, Beaverton, Oregon 97075

[6]R.S. Means Company, Inc., 100 Construction Plaza, P.O. Box 800, Kingston, MA 02364.

data?

Scheduling is the process of determining "a chronological itemization, often in chart form, of the sequence of project tasks."[7] When scheduling the activities of a project, are firms using the cost estimate to schedule? Does the superintendent determine the duration from experience or does the firm use productivity rates to determine a duration?

Controlling operations is also called real time construction management (RTCM). "RTCM consists of the ability to monitor the progress of a project, as it happens, and to respond timely and effectively to deviations from the plan that affect project cost, quality, or time."[8] When controlling the cost and progress of a project, how does the firm identify an activity that is over budget or behind schedule? How and when does a firm decide to accelerate an activity or project? How does management review overtime and productivity rates?

A claim is "a contractor's request for additional compensation or an extension of time pursuant to the contract terms."[9] When making a claim for added compensation, does the firm have a supportable case based upon contemporaneous historical records of cost, progress, and correspondence, or does it try to reconstruct cost and progress from incomplete records of its past operation? These topics are of great interest to The Ohio State University Construction faculty and are of vital

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[7]Chandler and Smit, ed., p. 497.

[8]U.S. Army Corps of Engineers, Construction Engineering Research Laboratory, draft report, unpublished.

[9]Chandler and Smit, ed., p. 115.

importance to the construction industry.

1.2 Project Administration Model

While project administration has a very broad scope, this study will focus on the firm's in-house activities and responsibilities within four phases (estimating, scheduling, controlling, and claiming) defined above. Of specific interest is the information flow from one phase to the next, what decision criteria are used within each phase, and what type of feedback is used to check reliability of estimates, schedules, and productivity.

Ideally, the four phases specified in this study constitute the core of project administration tasks. The process starts with an estimate of costs for the proposed project. If a contract is awarded to the firm, detailed scheduling of activities occurs. After the construction project begins, firms monitor work progress and cost. During and following construction, firms submit claims for added compensation.

By evaluating the data, methods of analysis, and handling of responsibilities from one phase to the next the researcher will determine if data and analysis methods in each phase are consistent[10] with preceding and following phases. To more fully explain the notion of consistency, let us consider two hypothetical construction firms, X and Y.

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[10]Consistency - "compatibility or agreement among successive acts, ideas, or events." William Morris, ed., The American Heritage Dictionary of the English Language (Boston: Houghton Mifflin Company, 1979), p. 284.

Firm X operates with procedures viewed as following established standards of practice within the construction industry. When estimating, the firm uses historical records of productivity to predict costs. The same productivity rates are used to find durations of activities when scheduling. The schedule is finalized after coordination between the estimators and field operation management personnel. During controlling operations, productivity rates and quantities of work completed are monitored periodically. In the event a claim for added compensation is filed, the firm uses the same estimating, scheduling, and controlling data to justify the claim. Firm X operates with consistency because of the compatibility and agreement among successive acts (Figure 1).

Firm Y, on the other hand, operates below the established standards of practice. Firm Y estimates quantities and cost from experience and judgement. The firm schedules the project by sending out the quantities and blue prints to an outside agency who develops a detailed schedule. However, the firm controls the project with a bar chart that the construction manager developed because he could not understand the CPM given to him by the outside agency. If a claim is filed, the firm rushes to create cost data to justify the estimate and develops additional schedules and progress reports with quantities of work completed. Firm Y does not have compatibility or agreement among its successive acts. Firm Y does not operate consistently (Figure 2).

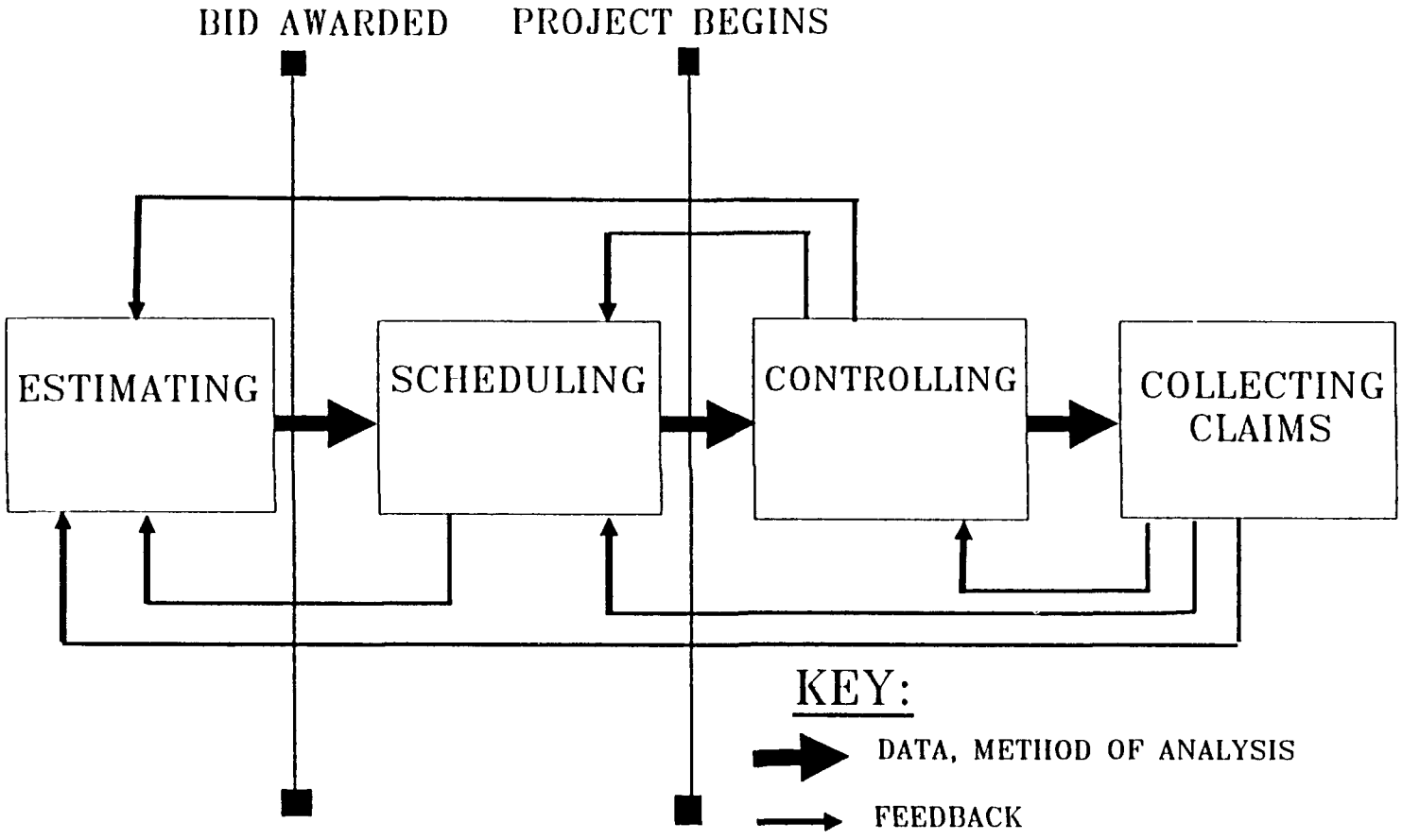

Figure 1: Project Administration Model With Consistency

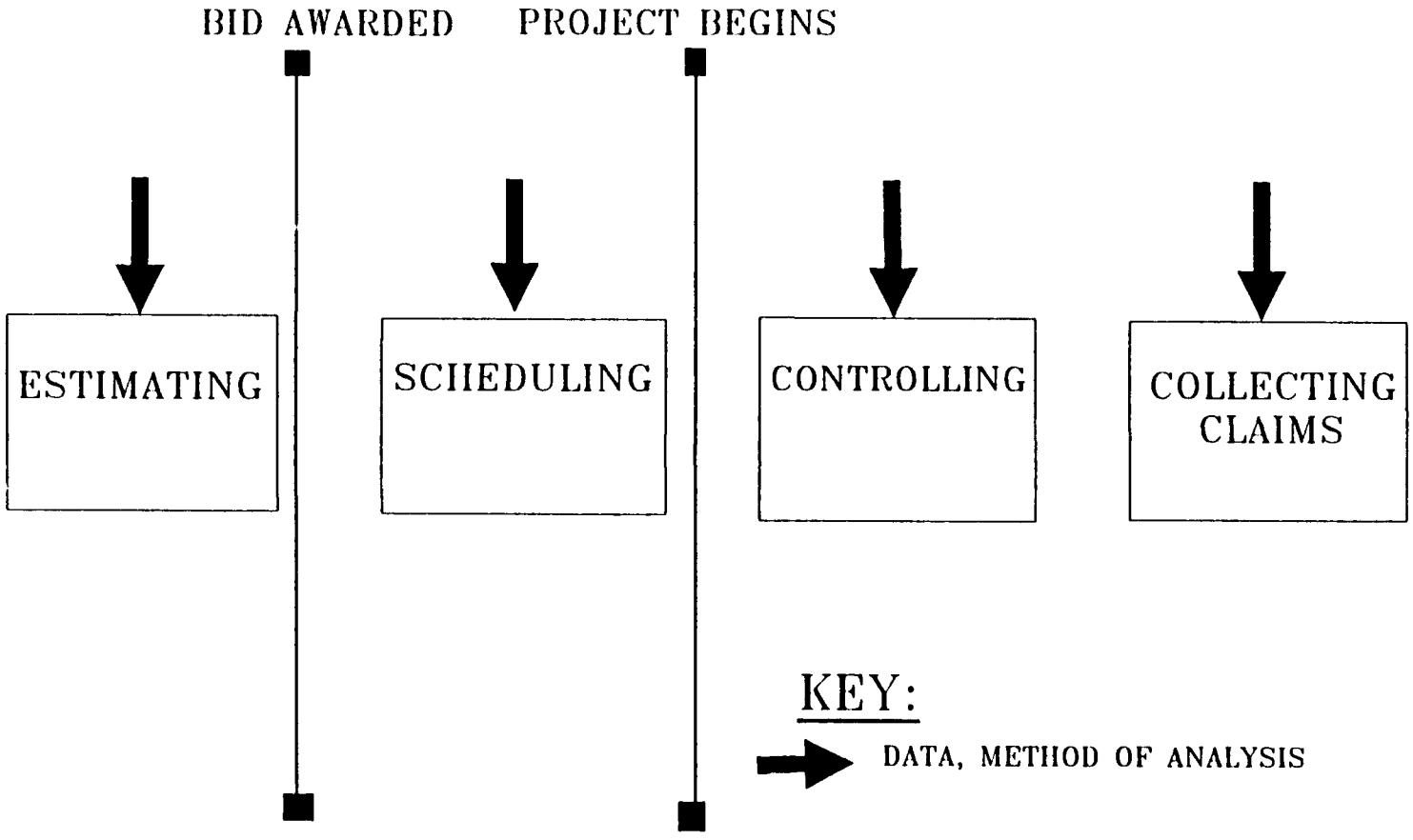

Figure 2: Project Administration Model Without Consistency

1.3 Study Objectives

The first objective of this study is to determine if there is consistency of data and methods relied upon in estimating, scheduling, controlling, and collecting within the interviewed companies. Investigation of consistency within the companies will require examination of procedures of each company through the inter-relationship of the four phases.

The second objective of this study is to document the current practices of the contractors in project administration in the construction industry. The second objective is closely related to the first objective and will be evaluated from the same data.

The third objective is to identify the interviewed firms perceived barriers to improvement in project administration. This study will summarize the findings of the researcher based on interviews of successful Ohio contractors and will not try to generalize about the construction industry as a whole.

1.4 Potential Research Benefits

This research could lead in time to more accurate cost estimating, more reliable scheduling, and better monitoring of progress. Findings could help managers in establishing methods for real time construction dispute resolution and prompt collection of claims for added compensation. Faculty members could use the reported areas of concern to enrich the subject matter of current or future courses.

1.5 Organization

This thesis will contain the following Chapters: I) Introduction, II) Plan of Study, III) Survey Results, IV) Discussion of Results, and V) Conclusions and Recommendations. Appendices following Chapter V include information provided to the firms before the interview, and a tabulation of responses at the time of the interviews. The final item is a list of references cited.

CHAPTER II

PLAN OF STUDY

2.1 General Approach

This chapter will detail how the study objectives will be achieved and the method of collecting data. The study objectives specified in section 1.3 will be met by analyzing the responses to survey questions. The general procedure followed in this study consisted of calling contractors to request their participation, providing them with the objectives and topic questions of the study, and conducting the on-site survey interview.

2.2 Survey Questions

The information received from asking the survey questions will allow the researcher to evaluate the three stated objectives of this study. Objective one, pertaining to consistency, will be examined in light of the responses to seven survey questions. Objective two, documenting current practices, will use the same data from the seven survey questions of objective one. Three survey questions will provide responses for objective three, identifying barriers to improvement in project administration. Figures 3 and 4 display the stated objectives along with the corresponding survey questions.

Objective 1:

To determine if there is consistency of data and methods relied upon in estimating, scheduling, controlling, and collecting within the interviewed companies.

Objective 2:

To document the current practices of the contractors in project administration in the construction industry.

Survey Questions:

Q1) What data is relied upon and what method is used to develop your cost estimate?

Q2) What data is relied upon and what method is used to develop construction schedules?

Q3) What data is relied upon and what method is used to track job progress and cost during construction?

Q4) If the firm uses acceleration, what criteria are used to make the decision and what type of acceleration is used: 1) overtime, 2) multiple crews, 3) multiple shifts, 4) four day work week or other nonstandard practices?

Q5) What data is relied upon and what method is used in preparing claims for added compensation, litigation, mediation, negotiation, or arbitration?

Q9) Do you analyze the reliability of your estimate, schedules, or productivity?

Figure 3: Study Objective 1 and 2 with Corresponding Survey Questions

Objective 3:

To identify the interviewed firms perceived barriers to improvement in project administration.

Topic Questions:

Q7) What are your firm's three most important factors in determining success in the project administration areas covered previously?

Q6A) Can you identify areas of improvement needed in your firm relating to questions 1-5 above?

Q6B) Are there any barriers that prevent you from achieving your goals in these areas?

Figure 4: Study Objective 3 with Corresponding Survey Questions

The researcher decided to ask the firms two preliminary questions before asking the direct question pertaining to barriers. The researcher desired a more varied response by talking about broad positive factors relevant to success and ending up with the question on barriers to improvement.

2.3 Methodology

The objectives of this study required that the researcher personally interview construction firms. The selection of construction firms was not random. The

researcher called successful construction firms in the greater Columbus area that belonged to the Ohio Chapter of the Associated General Contractors of America (AGC), or the Builders Exchange of Central Ohio. The researcher contacted the firms by phone and asked to speak to the President, Vice President, or Chief Executive Officer (CEO). The AGC listings contained names of the prominent officers within the companies. If the firm listed more than three officers, the researcher assumed that the company was large and would ask for the Vice President first, and if he was not available, the CEO. In the smaller firms, those with only one or two officers listed, the researcher would ask to speak to the President first and if he was not available, the Vice President. The goal was to interview an individual in upper management familiar with the entire project administration process and the decision making process. Once in contact with one of these individuals, the researcher identified himself as a graduate student in the Civil Engineering Department, The Ohio State University and the purpose and topic of the study. The researcher offered to send a cover letter (Appendix A) and the Interview Guidelines (Appendix B) that would be followed in the interview.

The cover letter identified the following: the researcher and his advisor, an invitation to participate in the study, and that the information and sources would not be disclosed in the study or to any other parties. The Interview Guidelines stated the original objectives of the study along with the topic questions that the interviewer would ask in the interview. An unstated goal of the Interview Guidelines was to allow the firm to prepare its answers before the interview to help save both parties'

time. Additionally, the Interview Guideline informed the firm that the interview would take approximately one hour.

Before the conclusion of the initial phone conversation, the researcher stated that he would send the cover letter and Interview Guidelines. Next the researcher asked for an appropriate time to call back to see if the firm would agree to be interviewed. If the firm agreed to an interview on the first call, an appointment was made. Because most of the firms listed in the AGC magazine listed a fax telephone number, the researcher decided to fax the majority of the correspondence. This includes firms that agreed to an interview on the first call. A follow-up call to the remaining firms completed two tasks: it identified whether the firm would be willing to be interviewed and set a specific appointment to conduct the interview.

The researcher took a copy of the Interview Guideline to keep written notes of the firm's procedures. Additionally, the researcher asked for permission to tape record the interview as a backup. This allowed the researcher to focus more attention on the subject matter instead of taking notes. Before actually starting the interview, the researcher asked questions pertaining to the profile of the firm. This allowed the researcher to categorize the firms when making comparisons. The firm profile questions include:

1) Type of work?
2) Age of firm?
3) Scale of jobs ($)?
4) Annual Value of Work ($)?
5) Typical types of contracts?

CHAPTER III

SURVEY RESULTS

3.1 Introduction

This chapter provides the results of the survey. Rather than specifying the firm's responses to the nine survey questions, the researcher grouped like responses together and reported to what extent differences existed. The firm's specific survey responses plus some other pertinent data are provided in Appendix C. The survey questions are presented in the appendix in the same order as discussed in Chapter IV.

3.2 Characteristics of the Firms

Twenty firms were interviewed. They consisted of contractors located predominantly in central Ohio and members of either the Associated General Contractors of American (AGC) or The Builders Exchange of Central Ohio. The annual sales in dollars ranged from $1.3 million to $200 million. Fourteen of the firms were general contractors and the remaining firms were subcontractors. One of the general contractors classified itself as both a general contractor and construction manager. Within the group of subcontractors, the annual sales in dollars ranged from $2.5 million to $25 million. Three of the subcontractors

classified themselves as technical trades (i.e. mechanical, electrical, etc.). Table 1, Characteristics of the Firms, identifies the firms as firm A,B,...T and ranks them according to annual sales in million dollars. Each firm is categorized as a general contractor or subcontractor with a short description of the type of work.

3.3 Survey Questions

Question 1: What data is relied upon and what method is used to develop your cost estimate?

The majority of the firms (15/20) use historical cost data with productivity rate (unit cost) factors. After completing a quantity take-off of the project, the firms use the productivity rates to determine their cost to complete the project.

The remaining firms (5/20) obtained their cost estimate by comparing historical cost data from similar projects completed in the past to the actual quantity take offs for the current project. By using knowledge and experience, the estimator would determine a cost estimate for the proposed project. These firms were characterized by smaller annual sales and consisted of two subcontractors and three general contractors. One subcontractor noted that they recently obtained a new estimating program and hoped to use their own productivity rates within two years.

Table 1: Characteristics of the Firms

Firm	Annual Sales Million $	Type of Firm	Description
M	S	GC	Commercial, Industrial, Maintenance
E	S	SUB	Acoustical Ceiling
N	S	GC	Commercial, Industrial
T	S	SUB	Sheet Metal
I	S	SUB	Exterior Walls
B	S	GC	Commercial
K	S	SUB	Metal Walls & Studs
A	M	GC	Commercial, Industrial
F	M	GC	Commercial, Industrial, Institutional
P	M	GC	Commercial, Industrial, Institutional
C	M	GC	Highway
D	M	GC	Commercial
J	M	GC	Commercial, Industrial
R	L	SUB	Mechanical
S	L	SUB	Electrical
O	L	GC	Commercial, Institutional
Q	XL	GC	Commercial, Health Care, Institutional
H	XL	GC	Commercial, Industrial
L	XL	GC	Highway, Earthmoving, Mining
G	XL	GC	Commercial, Industrial, Institutional

Key: S - 1 to 10 L - 21 to 30 GC - General Contractor
M - 11 to 20 XL - 75 to 225 SUB - Subcontractor

Question 2: What data is relied upon and what method is used to develop construction schedules?

The majority of the firms (13/20) use productivity rates from the estimate in conjunction with the expected project conditions and employee work experience to develop durations for activities in the construction schedule.

The remaining firms (7/20) used the dates that were stipulated on the contract and adjusted the work crews to complete the project. After completing the quantity take-offs, the firms used their own experience and expected project conditions to determine the crew sizes. This was especially true of the subcontractors (4/6). Another subcontractor, although it used productivity rates to determine activity durations, would alter crew sizes in order to complete their section of work within contract terms. Thus, actually five of the six subcontractors would alter crew sizes.

Question 3: What data is relied upon and what method is used to track job progress and cost during construction?

All the firms except one track progress using weekly, biweekly, or monthly reports comparing scheduled percent complete to the reported percent complete of the scheduled activities. The one exception monitored progress exclusively by use of a bar chart with scheduled activities evaluated by on-site inspections by the project manager at least once a week. Only five firms used productivity rates to monitor progress. One of these five firms is a subcontractor that only monitors one specific activity by using productivity rates. Another one of the firms using productivity rates

is also a subcontractor while the remaining three are general contractors. Six of the twenty firms do not track any daily or weekly quantities of work completed. Four of these six were subcontractors.

When controlling costs, all of the firms tracked daily or weekly man-hour reports and produced weekly or monthly cost reports comparing the actual man-hour costs to the estimated man-hour costs. This report can be compared to the percent complete to date to put the man-hour costs in perspective. One of the larger general contractors produced a monthly resource histogram comparing actual verses estimated man-months to control and monitor costs. Most of the firms acknowledged that labor productivity contained the most risk in projects and therefore concentrated on monitoring the labor costs because material costs do not vary as much.

Question 4: **If the firm uses acceleration, what criteria are used to make the decision and what type of acceleration is used: 1) overtime, 2) multiple crews, 3) multiple shifts, 4) four day work week or other nonstandard practices?**

None of the firms used analytical methods to determine what was the firm's most efficient form of acceleration. The majority of the firms (17/20) would only work overtime for two to three weeks because of the loss of productivity. These same firms would schedule long-term overtime only at the direction of the owner. If the amount of work justified it and crowding was not an issue, firms would hire

a second crew because of the high cost of overtime.

The exceptions to this case involve the following three firms. A capital intensive firm decided overtime was justified because of the higher cost of idle equipment. In fact, the firm operated two shifts per day with overtime. Another firm stated that because of the seasonal nature of their highway construction that overtime is used as a labor bonus to attract workers. A final firm declared that since it did not have any labor resources, it was up to the subcontractors to decide how to meet the terms of their contract. It also should be noted that three technical subcontractors (mechanical, electrical, etc.) revealed that they prefer accelerating by using a second shift to prevent crowding.

Question 5: **What data is relied upon and what method is used in preparing evidence for litigation, mediation, negotiation, or arbitration?**

All the firms felt that the superintendent's daily log, tracking correspondence, and giving prompt notice were the keys to success although most of the firms had never been in litigation.

However one general contractor and one subcontractor thought that the initial schedule of the project was the most important document. Three general contractors and three subcontractors asserted that they had used productivity rates in claims.

Question 6: Can you identify areas of improvement needed in your firm relating to questions 1-5 above? Are there any barriers that prevent you from achieving your goals in these areas?

The researcher asked for three areas of improvement from each firm but only received a total of thirty eight responses. Every firm gave at least one response. The answers given can be grouped as: information flow and reports, computers, estimating, and personnel.

Almost one third of the replies (12/38) or one half of the firms (10/20) stated that the flow and timeliness of information within the office or the field needed improvement. Specifically, three firms desired better daily log reports from their superintendents. Four of the responses pertained to computers: obtaining, using for job costing reports, and using for better project take-offs. Another seven responses dealt with the need for improved estimating, productivity rates, man-hour data, and for an increased number of estimates. The final group, personnel, received five responses from four firms. The firms stated that they wanted to hire recently graduated engineers with better training and make work experience in the specific areas of: construction, blue prints, and computers. Additionally they wanted people willing to take responsibility.

The remaining responses for areas of improvement did not fall into a specific category but can be listed (followed by the number of responses in parenthesis):

Document claims better (2)
Scheduling properly (2)
Quality construction (1)
Cooperation among other trades at project (1)
Marketing of firm (1)
Throw out Davis - Bacon Act (1)
None (1)
Get more work (1)

The second issue investigated in question 6 was barriers preventing achievement of the firm's goals in questions 1-5. The answers provided by the firms were placed into four groups: cost of computer hardware and software, regulatory demands, personnel, and fear of change.

Five firms, two subcontractors and three general contractors, reported that the amount of money and time needed to implement computer hardware or the current construction software programs were barriers. In the second group, general contractors stated that government or regulatory demands on resources were barriers. The next two groups were reported by four firms with a mix of one subcontractor and three general contractors. In the area of personnel, firms would like to hire better quality workers willing to accept more responsibility. Also, firms mentioned an institutional fear of changing operations or the fact that the owner was afraid of change.

The remaining responses are provided to show minority viewpoints. Three firms, with a mix of one subcontractor and two general contractors, stated they

wanted graduating engineers with better experience and technical skills.

Individual general contractors provided the following examples of barriers:

1) The prevailing wage laws.
2) The defensive climate between the owner, Architect / Engineer (A/E), and contractor.
3) Estimators do not get time to visit the field.
4) Poor communication between the field and the office.
5) Open shops are underbidding the union shops.

One subcontractor provided the following examples of barriers:

1) The competitive industry prevents the overhead cost of tracking productivity rates.
2) Unions would not accept productivity studies.
3) Labor halls limit the number of new workers by year.

Other subcontractors stated barriers of:

1) Other subcontractors crowding the project site.
2) Owners/AE's do not want to pay for change orders resulting from inadequate plans and specifications.
3) Owners want low cost but not quality. (2)

Question 7: What are your firm's three most important factors in determining success in the project administration areas covered previously?

The firms responded with a total of fifty six answers that can be categorized into six major groups: factors of quality, price control, personnel, business ethics, communication, and scheduling.

Quality issues received the most responses, twelve of the fifty six. Quality control and providing quality to the client were very important issues to the firms. The next highest priority issue for the firms was price control. Nine of the fifty six responses considered accuracy of estimates, knowing true costs for activities, and

monitoring costs as factors important to success. Seven of the responses stated that retaining quality personnel and training them were key factors. Another seven responses dealt with business ethics such as professional conduct, fairness, trust, and proper relations with subcontractors.

Seven responses revealed that communication, openness to ideas, and supportive management were important factors. Another five firms stated that proper scheduling, breakdown of activities, and monitoring of schedules were important.

The remaining responses to question 7 occurred only on a limited basis. Three responses highlighted the need for a flexible and controllable work force. All three of these firms predominantly used their own labor force in construction. Another two responses cited proper interpretation of construction documents. Two more firms stated that follow-through of paperwork and taking care of details were important. One response stated that a firm needed to find and operate in a proper job niche (sector). And finally, one firm cited that making a profit is an important factor in determining success.

Question 8: How does your firm insure a proper transfer of data, objectives, and assumptions from one phase of administration to the next?

This topic appears to follow definitive trends. Ten of the fourteen larger general contractors utilize a preconstruction meeting to transfer data, objectives, and assumptions while the remaining four general contractors use single-source

responsibility to manage a project. The smaller general contractors use single-source responsibility when the Project Manager stays with a project from estimation to completion.

The subcontractors show a mix: two using single-source responsibility, three using a preconstruction meeting, and one subcontractor that does neither. The subcontractor using neither states that he doesn't believe in meetings and that his superintendents are smart enough to figure out how to run a job from the blue prints and material list.

Question 9: Do you analyze the reliability of your estimates, schedules, or productivity?

The norm for this response was that firms check their estimates and schedules weekly with the man-hour labor reports, and the firms check monthly when reviewing the cost reports and material reports. However, one subcontractor conducted a very detailed and formal briefing after every project.

The exception for this topic was that two firms cited that they only checked reliability if a project had a major problem.

3.4 Other Areas of Interest:

Issue 1: Do firms use computers?

The majority of the firms (17/20) use computers, mostly for cost and progress reports and scheduling. The three firms that did not use computers were the three

smallest by annual sales in dollars.

Issue 2: How many firms use computerized estimating programs to estimate projects?

Twelve of the seventeen firms with computers use an estimating program. Of the five firms with computers that do not use an estimating program, three of the firms are among the four smallest general contractors.

3.5 Significant Practices or Comments by the Firms.

This section will outline significant practices or comments by the firms that do not necessarily fall into the categories of the nine survey questions. Additionally, comments that strengthen or expand summarized topic areas will be included. Each firm's comment or practice is identified with a asterisk (*).

* Estimators identify approximately twelve activities for which productivity rates are tracked for each job. Field personnel report back to the estimators so the estimators can monitor progress and make improvements on future estimates.
* Estimators track unit costs for the firm and the unit cost of three subcontractors per specialty to help keep options open and to insure competition among the subcontractors.
* A specialty subcontractor tracks approximately thirty activities for productivity rates.

* Estimator completes a bid and then the Project Manager duplicates the effort independently. Afterwards, the two estimates are compared. The firm operates like this to insure a proper check of the estimator's bid.
* General contractor maintains fifty carpentry productivity rates for the normal 25% of the project work the firm constructs. The firm subcontracts the remaining 75% of the contracts.
* Subcontractor only tracks productivity rates on selected activities and only for certain jobs because it involves too much paperwork.
* General contractor determines who the project manager (PM) will be for a particular project and the PM works side by side with the estimator. The estimator also helps monitor costs during construction.
* General contractor does not use a computer but still estimates with productivity rates based on historical records in man-hours per unit.
* General contractor maintains productivity rates in man-hours per unit (MH/unit) and dollars per unit ($/unit) but only on selected activities.
* General contractor uses a developmental schedule in private contracts which acts as a decision schedule for the owner. Firm includes items such as zoning permits and A/E preliminary drawings on negotiated work.
* Subcontractor gives a rebate to the owner/general contractor if the subcontractor can schedule his work first without interruptions from other trades. This reduces crowding and disruptions from other subcontractors and ultimately improves productivity.

* General contractor uses cost reports that list the variance of the actual productivity from the estimated value.
* General contractor feels that if he tracks the quantity of work performed and the productivity rates, he should know at 25-30% complete if he is in trouble. Sometimes the firm only spot checks productivity.
* General contractor does not worry about completion date of project because the firm will hire resources to meet the schedule. The firm knows its cost and productivity rates and proclaims that acceleration is a specialty of the firm.
* General contractor states that availability of material and equipment is the most important factor in any decision concerning acceleration.
* Subcontractor states that on highly technical work he prefers overtime when accelerating in order to reduce mistakes from handing over to a second shift.
* General contractor has two project turn-over meetings. The first is a very brief and the second meeting occurs in 7-10 days. This gives the operations personnel a chance to look over the materials and develop questions.
* General contractor directs one of the PM's to take-off quantities for a future project and afterwards the estimator (President or Vice President) establishes prices.
* General contractor completes a "risk exposure analysis" prior to bidding on any job and then continually updates.
* General contractor thinks graduating engineers should know that the construction business is 95% people and 5% technical knowledge. They need to take some

business courses. Additionally, professors need to get in contact with the private practice.

* General contractor feels that a big problem in the industry is the poor quality of drawings from the A/E. He feels the profit margins are too low to make quality drawings.
* Subcontractor needs productivity data to better decide whether or not to purchase new tools and equipment.
* Subcontractor feels A/E need more money to produce better drawings.
* Subcontractor feels installation and fabrication drawings should be provided by the engineer,not his firm. The firm also absorbs the cost of coordinating drawings with other subcontractors.

CHAPTER IV

DISCUSSION OF RESULTS

4.1 Introduction

This chapter discusses survey question results in the context of how they relate to the stated objectives of the study. The researcher will discuss consistency and current practices based on the responses from survey questions 1-5, 8 and 9, and then discuss barriers to improvement based on responses to survey questions 6 and 7.

4.2 Consistency and Current Practices

Specifically, this study's first objective was to investigate if there is consistency of data and methods relied upon in estimating, scheduling, controlling, and claiming within the interviewed companies. The second objective was to document the current practices of the contractors in project administration in the construction industry.

Question 1: What data is relied upon and what method is used to develop your cost estimates?

Since the majority of the firms (15/20) use historical cost data with productivity rates to estimate, their procedures contribute to consistency. The firms obtain consistency in their estimates by knowing detailed costs based on varied job quantities. A general trend surfaced that contractors and especially subcontractors would only track specific activities for duration. Only a limited number of activities were tracked to reduce the overhead cost of collecting and processing data. One firm tracked approximately twelve activities per project while others maintained 30-50 in a data base. One of the larger general contractors reported maintaining a data base with 400 productivity rates for activities.

The firms that did not use productivity rates to estimate used their business knowledge and experience. These smaller firms displayed consistency in that they always compared the current project to similar jobs completed in the past.

Question 2: What data is relied upon and what method is used to develop construction schedules?

The majority of the firms (13/20) use productivity rates from the estimate to develop durations for activities in the construction schedule. This practice lends itself to consistency because the second phase (scheduling) logically follows the

productivity data from the first phase (estimating). This description of scheduling acknowledges that firms also consider expected project conditions when developing construction schedules. In fact, a large subcontractor will give the owner a rebate if the firm can proceed first so there will be no disruptions or crowding due to other subcontractors.

The remaining firms (7/20) use the dates prescribed in the contract to make their schedules. Work crews are adjusted to complete the project in the time allowed. The researcher can not justify a reason to classify this procedure as contributing to consistency. Because six of the seven firms were subcontractors, and subcontractors typically perform more routine and predictable tasks, presumably the subcontractor decided completing a detailed schedule was not necessary.

Question 3: What data is relied upon and what method is used to track job progress and cost during construction?

All the firms except one track progress using weekly, biweekly, or monthly reports comparing scheduled percent complete to the reported percent complete of the scheduled activities. This high number of responses reveals high agreement among the firms. However, when evaluating consistency within each firm this procedure does not promote consistency. Recall that the majority of the firms estimate and schedule using productivity rates while the form of control in the next phase is based on percent complete. Only five of the firms reported using productivity rates to monitor progress.

All of the firms tracked project costs by tracking daily or weekly man-hour reports and producing weekly or monthly cost reports comparing the actual man-hour cost to the estimated man-hour cost. Again the survey indicated a high level of agreement among the firms in this area. Within a firm, it appears that comparing the various cost accounts from estimated to actual is a consistent manner to operate.

Question 4: If the firm uses acceleration, what criteria are used to make the decision and what type of acceleration is used: 1) overtime, 2) multiple crews, 3) multiple shifts, 4) four day work week or other nonstandard practices?

There was universal agreement among the firms in the area of using statistical data to determine the firm's most efficient form of acceleration; none of them used statistical data. There was also agreement among the firms in that, based on job experience and knowledge of construction industry reports, 17 of 20 firms would not schedule overtime unless directed by the owner. Because of the loss of productivity, the firms would only work two to three weeks of overtime. Two of the three firms that would schedule overtime were capital intensive operations.

The decision of when and how to accelerate a project is part of the controlling operations phase, i.e. monitoring project cost and progress. When evaluating the consistency within a firm at the controlling phase, one must review the decision criteria for the previous phases. In most instances, firms use productivity rates in both estimating and scheduling, but the firms do not have data on various

productivity rates in acceleration conditions. Firms rely on what they perceive as industry truths about acceleration and do not use their own data.

Question 5: What data is relied upon and what method is used in preparing claims for added compensation, litigation, mediation, negotiation, or arbitration?

This area reveals agreement among the firms. All the firms felt that the superintendent's daily log, tracking correspondence, and giving prompt notice were the keys to success, although most of the firms had never been in litigation. The only firms that operate with internal consistency were the six firms that have used productivity rates in claims. If firms were to decide that they had been adversely affected in some manner and wanted to make a claim, it seems logical to use the data from the previous phases of project administration already used, i.e., the productivity rates used in estimating, scheduling and controlling.

Question 8: How does your firm insure a proper transfer of data, objectives, and assumptions from one phase of administration to the next?

The general contractors follow a trend of large firms using a preconstruction meeting to transfer information while the smaller general contractors use single-source responsibility. There is a definite trend among the general contractors. In evaluating consistency within the general contractors, obviously the smaller general contractors using single source responsibility have the most consistency because the

same person tracks a project from estimation to completion.

The subcontractors have the same two procedures plus a third option that prescribes no preconstruction meeting. The subcontractors are varied by size and craft and they do not follow any trend in the manner that they address this issue. There is no agreement among the subcontractors.

Question 9: Do you analyze the reliability of your estimates, schedules, or productivity?

The agreement among the firms in this area is substantial. The majority of the firms check their estimates and schedules with weekly man-hour reports and then check the monthly cost reports and material reports. The firms are checking costs during construction and then compare the bottom line to make corrections in future projects. Only one firm reported that its progress report contained a measure of variance of the estimated productivity to the actual productivity. No firms reported using statistical analysis on productivity rates or cost estimates.

4.3 Barriers to Improvement

This section will discuss this study's third objective which is to identify the interviewed firms perceived barriers to improvement in project administration. The specific survey results will come from questions 7 and 6. Survey question 6 will be broken up to reflect question 6A and 6B.

Question 7: What are your firm's three most important factors in determining success in the project administration areas covered previously?

This question investigates what the construction firms think is important to their success and therefore, it should be important to the agencies working with the construction firms. Other agencies should know the priorities of the customer to produce a better product or service. The firms provided responses that can be grouped as follows: quality, price control, personnel, business ethics, communication, and scheduling.

Quality control and providing quality to the client received the most responses. The next highest response revealed accuracy of estimates and knowing the true cost of activities as most import. In the area of personnel, firms feel retaining quality personnel and training them are key factors. Business ethics topics of interest are professional conduct, fairness, trust, and proper relations with subcontractors. In the area of communications, firms feel that communication, openness to ideas, and supportive management were important factors. And finally, that proper scheduling and monitoring of schedules were important.

Question 6A: Can you identify areas of improvement needed in your firm relating to questions 1-5 above?

Areas of needed improvement in the construction firms are in information flow and reports, computers, estimating, and personnel. Specifically, the firms want better timeliness of reports, better use of computer cost reports and computer

estimating, improved estimates, and increased quantity of estimates. The firms also want to hire graduating engineers with better skills in construction work, reading blue prints, and using computers. They also want engineers willing to take more responsibility. The above-named items reflect what the construction firms feel they need in order to improve. Other minority views were presented in question 6 of section 3.3.

Question 6B: Are there any barriers that prevent you from achieving your goals in these areas?

This question will allow interested parties to look into the operating environment of the construction firms and see what barriers inhibit them. The firms responded in areas that included cost of computer hardware and software, regulatory demands, personnel, and fear of change.

Firms reported that the amount of money and time needed to implement computer hardware or the current construction software programs were barriers. Firms stated that government or regulatory demands on resources were barriers (required reports or procedures). Firms would like to hire better quality workers willing to accept more responsibility. Firms mentioned an institutional fear of changing operations or the owner was afraid of change.

Individual answers provided by the firms presented in question 6 of section 3.3. There appears to be no trend in the individual responses between general contractors and subcontractors. Of particular note are the subcontractor's claim that

barriers include owners/AE's not wanting to pay for change orders resulting from inadequate plans and specifications, and owners wanting low cost but not quality. The construction firms feel these issues are barriers to their improvement in the current environment in which they work. The researcher acknowledges that several of the responses should be classified as problems and not barriers, however the researcher did not realize this until after the interviews. This discussion is based on all the responses received from the firms.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter will discuss the writer's conclusions based on the survey of twenty construction firms and present recommendations for future research. Additionally, the researcher will present findings derived from the analysis of significant practices or comments of the firms.

Recall from Chapter I that American competitiveness and economic well-being need the attention of top corporations and academia to collectively work towards integrating total quality management. As a means of achieving this integration, this researcher was tasked to make contacts with the construction industry. The researcher decided to evaluate project administrative procedures for consistency, document the current practices of contractors, and to identify the interviewed firms perceived barriers to improvement in project administration.

5.2 Conclusions

The firms displayed agreement in estimating because 15 of the 20 firms use historical cost data with productivity rates to estimate the cost of a project. Another 13 firms carry the productivity data forward to use when developing construction

schedules. This successive use of productivity rates from one phase to the next promotes consistency within the firms. Six of the seven firms not using productivity rates were subcontractors who use the dates of the contract to make their schedule. Because their work is more routine and predictable, the subcontractors decide a detailed scheduleedule is not necessary.

There is substantial agreement among the firms in the controlling phase. All the firms except one monitor progress by comparing scheduled percent complete to the reported percent complete. The same agreement exists among the firms when monitoring project costs. All the firms track man-hour reports comparing actual to estimated man-hours, usually on a monthly basis.

In the controlling phase, the majority of the firms appear to abandon the productivity rates used in estimating and scheduling in favor of using man-hour payroll data to monitor cost. Again, when monitoring progress, the firms using percent complete versus percent actual appear to abandon the productivity rates used in the first two phases. Apparently, the requirement for certified payroll records and the high cost of overhead to monitor productivity rates prevents other means of controlling operations. However, there was a minority of five firms that displayed consistency in that they used productivity data to monitor progress. Of particular note was one of the larger general contractors that stated at 25-30% complete you should know if you have a serious problem.

Another aspect of controlling a project is knowing when and what type of acceleration to use. There is agreement among the firms on this topic because most follow the industry standard of no scheduled overtime unless directed by the owner, and use overtime for only two to three weeks because of the loss of productivity. None of the firms have statistical proof as to whether overtime, multiple crews, multiple shifts, or non-standard practices are more efficient. Consistency is thus very low in the controlling phase of project administration.

In the last phase of the Project Administration Model, claiming, there was agreement among the firms. All the firms stated that collecting and tracking correspondence were the keys to success in litigation. Only six firms operated with consistency within their operations by using productivity rates in their claim. Although most firms had never been in litigation, and the situation to use productivity rates in a claim may have never presented itself, it seems logical to use productivity data from the previous phases to make claims.

Another issue that helps define consistency is how a firm transfers data, objectives, and assumptions from one phase of administration to the next. The general contractors displayed agreement among the firms because the larger firms use preconstruction meetings while the smaller general contractors used single-source responsibility. The six subcontractors did not show any agreement in this area.

The last area discussed will be the manner in which firms check the reliability of their estimates, schedules, or productivity. The basic component of this issue is

feedback. What data is used, where does the data originate, where is the data transferred, and how is the data used? The majority of the firms' feedback activities occurred in the controlling phase. By comparing estimated percent complete versus the actual percent complete, there was a feedback route from controlling to scheduling. The same can be said for the feedback route from controlling to estimating. The firms compared estimated cost to actual cost in man-hours. Only the five firms that use productivity rates to monitor progress get an immediate feedback on the original cost estimate using productivity rates.

In the last phase, claiming, feedback to the other phases rests mostly on grounds of proper documentation. Only six firms have used productivity rates in a claim. This information could be routed back into the previous phases to improve estimates or schedules based on the outcome of the claim.

To summarize all the components evaluated relevant to objective one, the researcher concludes that there is substantial agreement among the firms and marginal consistency of data used within the firms. Specifically, not following through with the use of productivity rates in the last two phases of the project administration model reduces consistency greatly.

This study's second objective was to document the current practices of the contractors in project administration in the construction industry. As stated earlier, the data obtained from the survey questions in objective one will be used to evaluated objective two. The researcher feels objective two was meet entirely by discussing what practices were or were not in agreement among the firms in the

course of discussing objective one.

The third objective of this study was to identify the interviewed firms perceived barriers to improvement in project administration. The researcher detailed questions to determine what was important to the firm's success, what areas needed improvement, and what barriers prevented improvement. Firms noted that important factors to success in project administration are quality, price control, personnel, business ethics, communication, and scheduling. The areas needing improvement were information flow and reports, computers, estimating, and personnel. The stated barriers were the cost of computer hardware and software, regulatory demands, personnel, and fear of change. Many of the barriers listed were actually problems.

5.3 Recommendations

The researcher's recommendations are grouped to address four different audiences. The four groups pinpointed for recommendations are: improvements for contractors within their firms, contractors as members of trade associations, owners, and construction education programs.

5.3.1 Recommendations to Contractors

Recommendations to contractors for improvements within their own firm are:

1) Construction firms should implement procedures to utilize productivity rates throughout the four phases. For the majority of firms this would only mean carrying the productivity data forward to use in the last two phases: controlling and claiming.

Firms will have the potential for more accurate estimating, scheduling, controlling, and better support for claims.

2) Construction firms need to only track significant or defining activities of their operations in order to cut down on the cost and time of overhead expenses.

3) Construction firms should monitor productivity at the 25-30% project completion point closely in order to determine if there is a serious problem. If the problem can not be isolated, then the firms should begin a 100% tracking account for all input costs and exact outputs, in case of future litigation. Although the firm may not have a baseline productivity rate for non-significant activities, the firm will have actual costs, durations, man-hour reports, and quantities placed or constructed.[1]

4) Construction firms should use statistical control methods to track the variance of their productivity and develop a more extensive data base to explore the possibility of other independent variables contributing to productivity. Firms should use multiple regression to see what other variables may become significant. Suggestions for variables to include are: daily record of man-hours and quantities produced, methods and parameters, type and capacity of equipment, foreman, time and cause of delay, weather, temperatures, precipitation, wind, site visits, and whether or not any activity is constrained due to process or equipment limitations.[1]

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[1]The concepts for recommendations 3 and 4 were taken from a discussion with Dr. Richard E. Larew, Associate Professor, Department of Civil Engineering, The Ohio State University, September 1991.

5.3.2 Recommendations to Contractors as Members of Trade Association

Recommendations to contractors as members of trade associations for improvements within the construction industry are in three parts. This section exists because opportunities for any one firm working alone to improve industry practices are minimal.

5) Trade associations should try to relieve the contractor of the apparent dilemma caused when an owner demands low cost instead of quality. A potential solution could be to change industry practices to something other than awarding to the low bidder. Other practices are readily in use around the world.

6) Trade associations should address the contractors concern about increased costs resulting from the low quality of bid drawings from the A/E. Currently contractors must use their own resources to produce many needed drawings. Additionally contractors pay for omission or mistakes in the course of completing an increased number of change orders.

7) Trade associations should insist on setting the precedent for the use of productivity data as a means of hastening real time dispute resolution. Using productivity data could save time and money by solving problems quicker, at the lowest level possible, and before the need for litigation.

8) Trade associations should lobby owners and design firms to retain A/Es responsible for design on contract during the construction phase. This will facilitate prompt responses to design problems encountered by the contractors.

5.3.3 Recommendations to Owners

9) Review the current practice of awarding contracts to the lowest qualified bidder.

10) Increase compensation for A/E operations in order to increase the quality of bid drawings and specifications. This will reduce errors and omissions and the need for change orders.

11) Retain services of A/Es responsible for design on contract during the construction phase (see recommendation 8 above).

5.3.4 Recommendations to Construction Education Programs

12) Construction education programs should aggressively implement a TQM program because the firms were very receptive to the researcher and the idea of industry and academia working together. As noted earlier, one general contractor stated that the construction industry is 95% people and 5% technical. This may give reason to re-evaluate priorities. This is not an acknowledgement of past failings but a recognition that the industry is changing. Another possible step for academia is to canvas the leading institutions and see exactly what they are doing to advance their programs.

13) Construction education programs should focus on areas of immediate concern of the construction industry such as: determine if variation in crew size significantly effects productivity, determine how and when construction firms change their productivity rates, and determine what form of acceleration is most efficient: overtime, multiple crews, multiple shifts, or other nonstandard practices.

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APPENDIX A

INTERVIEW COVER LETTER

T · H · E
OHIO
STATE
UNIVERSITY

Civil Engineering

470 Hitchcock Hall
2070 Neil Avenue
Columbus, OH 43210-1275

Phone 614-292-2771
FAX# 614-292-3780

Date

Company XYZ
111 1st Street
Columbus, Ohio 99999

Dear Sir,

Dr. Richard Larew and I are inviting you to participate in a mutual study to determine what information, data, or methods are used when making decisions in the areas of estimating, scheduling, controlling, and collecting claims for added compensation. This is a very important topic in the construction industry and is part of ongoing research in the Department of Civil Engineering, The Ohio State University.

This letter acknowledges the initial phone conversation with you that outlined the purpose and procedures of the study. To further our study, we want to interview your firm to determine the current practices of private firms in the industry.

Sources of information obtained in this interview will not be disclosed in our study or to any other parties. Enclosed is the Interview Guideline I will follow in this study. We look forward to the opportunity of interviewing you.

Sincerely,

Gregory Linville
Graduate Student
Construction Engineering
and Management

EXAMPLE ONLY

APPENDIX B

INTERVIEW GUIDELINES

INTERVIEW GUIDELINE
Construction Firm Visit
OSU - AUTUMN '91

Introduction

This Interview Guideline describes the content and the necessary procedures by the researchers and the firms in order to conduct a successful survey.

Objectives

The primary objectives of this study are:

1) To identify the data relied upon and the computational methods used by participating firms when estimating cost and scheduling work of "significant" activities for a standard five day per week, eight hour work day.
2) To identify how the firms assess the impacts of: 1) overtime, 2) multiple crews, 3) multiple shifts, 4) four day work week, or other non-standard practices.
3) To identify the views of participants concerning needed improvements in cost estimating and scheduling.
4) To identify the view of participants concerning barriers that may inhibit improvement in the firm's procedures for cost estimating and scheduling.

Information Needed Concerning The Participating Firms.

Support from management is required to get this study off the ground. This study will concentrate on the following nine topics:

1) What data is relied upon and what method is used to develop your cost estimate?
2) What data is relied upon and what method is used to develop construction schedules?
3) What data is relied upon and what method is used to track job progress and costs during construction?

INTERVIEW GUIDELINE (CONTINUED)

4) If the firm uses acceleration, what criteria is used to make the decision and what type of acceleration is used: 1) overtime, 2) multiple crews, 3) multiple shifts 4) four day work week or other non-standard practices?
5) What data is relied upon and what method is used in preparing evidence for litigation, mediation, negotiation, or arbitration? Was the data/method helpful in your case?
6) Can you identify areas of improvement needed in your firm relating to topics 1-5 above? Are there any barriers that prevent you from achieving your goals in these topics?
7) What are your firm's three most important factors in determining success in the project administration areas covered previously?
8) How does your firm insure a proper transfer of data, objectives, and assumptions from one phase of administration to the next?
9) Do you analyze the reliability of your estimates, schedules, or productivity?

Proposed Format For The Interview

The purpose of the interview is to discuss the nine topic areas mentioned in this interview guideline. The firm will give a summary of its procedures on the stated nine topic areas. This interview should last approximately one hour.

Copy of Thesis

I will provide the firm with a copy of the thesis if requested.

Gregory Linville
Graduate Student
Construction Engineering
and Management
The Ohio State University

APPENDIX C

SURVEY RESPONSES

Table 2: Survey Responses

Firm	Q1 Develop Cost Estimate	Q2 Develop Construction Schedule	Q3 Track Job Cost and Progress
A	Computer data base of productivity rates and costs	Productivity data determines activity durations	Daily report man hour and quantities of significant activities. Compare variance of productivity for 12 activities per job.
B	Knowledge and experience	Owner's contract dates plus experience	Superintendent uses bar chart, no daily report of quantities
C	Computer data base of productivity rates and costs	Productivity rate determines activity durations	Weekly report quantity, man-hours, and equipment hours
D	Computer data base of unit costs, firm also tracks unit cost of subs	Use key dates of the contract, firm will hire additional crew to complete	Biweekly reports: man hours in the field, dollar cost in the office, superintendent monitors in the field.
E	After quantity take off, firm uses experience and judgement	Owner/GC contract sets dates, superintendent sets crews	Superintendent checks productivity on project site, compare man-hours actual to estimated
F	Use man days to estimate from previous experience	Use man days from estimate plus job experience	Update bar charts: weekly progress reports, monthly cost reports

Table 2 (continued)

Firm	Q1 Develop Cost Estimate	Q2 Develop Construction Schedule	Q3 Track Job Cost and Progress
G	Manual quantity takeoff, price based on unit price data from historical records, also use Walker and Means	Quantity estimate, historical productivity data, and milestones	Daily track man-hours, quantities, and coded activities for weekly progress meetings. Detailed accounting system used for cost meetings every 2 to 4 weeks.
H	Historical data base of unit costs	Owner sets start-stop dates, use crews and productivity rates from the estimate	Weekly man-hours and quantity report compares actual to estimate, monthly cost reports compares actual to estimate
I	Daily productivity rates from 30 activities the firm tracks	The GC will give window of construction, crews will be formed based on quantities and productivity from the estimate	Compare man-hour and cost to estimate, variance calculated for weekly cost and progress report for commercial projects
J	For negotiated work use Timerberline updated with own productivity rates of 50 carpentry activities	Estimator and PM schedule separately and then check and compare. Use productivity rates to get durations for activities.	Superintendent verifies quantities, PM verifies cost every 2 weeks, subcontractor and owners sign off on schedule before each project

Table 2 (continued)

Firm	Q1 Develop Cost Estimate	Q2 Develop Construction Schedule	Q3 Track Job Cost and Progress
K	50% of estimate based on estimator's experience. Plans & specs inaccurate, use edge program for synthetic plastics.	Subjective process, subcontractors hedge on GC being late	Computerized weekly job summary report, 100-150 jobs per week, only track productivity for specific jobs
L	Historical performance data, cost data, and equipment performance information	Bid data used from assumed productivity rates to determine days	Daily report man-hours, crew, quantity per shift: monitored by office. Monthly report is used to manage. Productivity monitored.
M	Use takeoff quantities plus past job experience	Owner sets dates, experience and logic make schedule	Post man-hours and costs weekly, project manager checks job weekly, bar chart used
N	Use productivity rates in MH/Unit, also Means, and Walker	Use productivity rate and crew size to get durations for activities	Track crew hours and quantities daily. Labor, equipment, and material monthly by percent to the owner. Report cost to complete every 2-3 months to owner.
O	Use historical productivity data plus experience. Takeoff manually, productivity rates for 400 activities.	Use experience from engineer and superintendent plus productivity rates for repetitive activities	Weekly man-hours, crew output, materials, and monthly cost reports, traveling superintendent reports progress also

Table 2 (continued)

Firm	Q1 Develop Cost Estimate	Q2 Develop Construction Schedule	Q3 Track Job Cost and Progress
P	Historical cost data plus experience, use productivity rates, take off manually	Convert bid $ to man-hours with crew, productivity rate gives duration, plus experience	Weekly man-hour and quantity report. Recap running monthly. Bar chart used visually on site.
Q	Use historical productivity rates, cost data, and experience to develop cost estimate, check off with subcontract's estimates	Use productivity rates from similar projects to get durations. Usually let subs get detailed, firm does not.	Daily construction reports include man-hours, crew, activities. Produce monthly histogram comparing man-months of actual to estimate dollars.
R	Use Mechanical Contr. Assoc. of AM take off, adjust to own historical records	CM or GC will finalize after checking with firm. May alter crew if estimated schedule differs from contract schedule.	Computerized man-hours and cost reports tracked weekly or monthly
S	Historical cost and productivity rates plus data from the National Electrical Contractors of America.	Use productivity rates from the estimate, acter to fit the schedule selected by the Owner/PM.	Weekly man-hour reports compare estimated man-hours to expended, also compare man-hours to percent complete.
T	Use owner determined productivity rates within estimation computer program	Fit work from estimate into schedule given by the GC, use estimate productivity rates to determine durations	Weekly man-hours report, compare cost monthly: estimated to actual, to amount to complete based on percent from man-hour costs.

Table 2 (continued)

Firm	Q4 Criteria and Type of Acceleration	Q5 Preparing Claims	Q8 Proper Transfer of Data, Objectives, and Assumptions
A	Will not schedule extended overtime unless the owner directs	Firm uses schedule, daily log, and correspondence. Key is tracking real time progress and giving prompt notice. Firm prepares risk management report.	Preconstruction meeting
B	Will use overtime, seldom use multiple shift or multiple crews	Prompt notice and pictures of project	Single source responsibility
C	No data analysis, overtime is a labor bonus for seasonal work. Sometimes use multiple shifts on big projects.	Superintendent's daily log	Single source responsibility
D	Use only spot overtime	Owner decides when and if to accelerate project. He will pay for the cost or move back completion date of project.	Roll over meeting. Estimators brief field operations
E	Use overtime if owner directs	Never in litigation	Single source responsibility
F	Will use overtime	Correspondence and transmittals	Preconstruction meeting that follows a checklist

Table 2 (continued)

Firm	Q4 Criteria and Type of Acceleration	Q5 Preparing Claims	Q8 Proper Transfer of Data, Objectives, and Assumptions
G	Incidental overtime is OK, long term is a problem, firm uses judgement to decide on type of acceleration	Daily logs and schedules are most important. Hard to prove unit cost in a claim.	Turnover meeting
H	Material delivery is most important factor. Spot overtime is OK. Working 5x9's and 1x8 is best.	Put owner on notice	Project team meeting hands over information. Later a 2nd meeting to follow up.
I	Seldom use overtime past 3 weeks	Superintendent's report of requests and job conditions. Firm has used productivity rates in negotiation.	Project superintendent help with the estimate. After project, compare cost and quantity to the estimate.
J	Short term overtime OK, long term if owner directs	Detailed job meeting minutes. Never in litigation.	Project turnover meeting
K	Firm doesn't like overtime: productivity loss- 20% Saturday and 50% Sunday.	The original schedule and documenting delays are most important	No formal hand over. Firm does not believe in preconstruction meetings.

Table 2 (continued)

Firm	Q4 Criteria and Type of Acceleration	Q5 Preparing Claims	Q8 Proper Transfer of Data, Objectives, and Assumptions
L	Capital intensive project-firm works six days double shift because overtime cost is insignificant. Use more crew or equipment for labor intensive acceleration.	Only 1 claim in 20 years. Firm has used productivity rates in negotiating.	Estimator and PM work hand and hand throughout project
M	Try not to schedule overtime. Short term is OK.	No court cases	Single source responsibility
N	If acceleration requires greater than 2 hours per day, firm will hire a second crew. Productivity goes down to 80% at 5x10's.	No court cases	Single source responsibility
O	Only spot overtime. Will use multiple crews or multiple shifts if owner directs.	Normal documents and correspondence firm used productivity rates in claim and negotiations	Horizontal control now - traveling superintendents visit project sites. Firm moving towards more vertical control, will omit traveling superintendent.
P	Seldom use multiple crews or overtime. Only use spot overtime.	Correspondence and checking specs and prints are important. One case pending using productivity rates.	Five PM takeoff quantities then two estimators (President and V.P) set prices

Table 2 (continued)

Firm	Q4 Criteria and Type of Acceleration	Q5 Preparing Claims	Q8 Proper Transfer of Data, Objectives, and Assumptions
Q	Firm lets subcontractors decide how to accelerate because they are under contract to perform	Detail daily construction report. Use original schedule plus impacted schedule in cases.	PM helps estimator to estimate project. Estimator prepares report for operations hand over meeting.
R	Only use spot overtime. Schedule overtime if owner pay: Prefer to use 2nd shift to reduce crowding. Usually need overtime on large jobs to attract labor.	Daily log reports and correspondence firm has used productivity rates in negotiations	Estimator and sales conduct turn over meeting to the project manager. Follows 10 page checklist form, completely briefed.
S	Use all types of acceleration. On technical projects use O.T., on labor intensive use 2nd shift. Use NECA productivity factors.	Use NECA standards plus own productivity rates in negotiating with owner	Single source responsibility
T	No scheduled O.T. past 3 weeks. Prefer second shift to prevent crowding.	Correspondence and documents	Estimator briefs superintendent, superintendent builds project, PM tracks cost and progress

Table 2 (continued)

Firm	Q9 How Measure Reliability	Q6A Areas of Improvement	Q6B Barriers to Improvement
A	Cost reports list variance of productivity rate for 12 significant activities	1) Computer training of management and foremen	1) Generation gap causing fear of computers
B	Evaluate cost reports for man-hours and materials	1) Better field reports and correspondence 2) Notify owner promptly 3) Spend more time estimating	1) Better people with more responsibility
C	Evaluate weekly reports for costs, man-hours and compare bar charts	1) Communication between the field and office	1) Family hierarchy 2) Respect for new ideas
D	Informally after a project ask why miss a section (why in error)?	1) None	1) None
E	Only on difficult jobs	1) Better access to job records 2) Computerize job cost	1) Money 2) Priorities of owner
F	After buy out a job, will see how close to estimate	1) Scheduling 2) Progress reports 3)Tracking quantities constructed	1) Communication between field and office 2) Cost and burden of record keeping 3) Tracking data
G	Weekly and monthly meetings check reliability. Manually check every estimate by hand.	1) Superintendent's log reports	1) Estimators don't get to the field 2) Estimators are interrupted

Table 2 (continued)

Firm	Q9 How Measure Reliability	Q6A Areas of Improvement	Q6B Barriers to Improvement
H	During project with weekly and monthly reports and after project	1) Want superintendents to take more responsibility 2) Want new engineers to read blue prints	1) Better people (employees) 2) School course requirements at the undergraduate level.
I	Weekly progress and cost reports	1) Upgrade computers 2) Timeliness of reports 3) Use data analysis	1) Labor training 2) Lack of labor interest 3) competition of value versus dollars
J	Weekly progress and biweekly cost reports	1) Communication 2) Quality	1) Defensive climate of industry - us versus them
K	Will not analyze unless major problem, 150 active jobs with only 3 estimators	1) Better productivity rates 2) Better computer takeoffs 3) Better experienced younger people	1) Labor communication and writing skills 2) Requirements for EEO, Bonding, Safety 3) Time to implement computers
L	Monitor daily, weekly, monthly with man-hour, productivity and cost reports	1) Communication to foreman 2) Feedback	1) Foremen accept more responsibility
M	Weekly update and monitor, make corrections	1) Get more work	1) EEO laws 2) Paperwork
N	Compare actual to estimate on weekly and monthly reports	1) Computerize 2) Complete more estimates	1) Open shops are under bidding union shops

Table 2 (continued)

Firm	Q9 How Measure Reliability	Q6A Areas of Improvement	Q6B Barriers to Improvement
O	Evaluate reports during construction. After action meeting when complete.	1) Cost reporting 2) Man-hour data	1) EEO laws 2) Minority business enterprises
P	Monitor weekly and monthly reports, compare final cost to estimate	1) Marketing 2) Repeal Davis-Bacon Act	1) Prevailing wage law 2) Strict compensation
Q	Compare estimate to buy out cost; monthly, quarterly, and yearly report cost to complete. Cost per quantity always updated.	1) More complete schedules - Government jobs require more detail 2) Better record keeping for man-hour and productivity rates	1) Cost of computer application and software 2) Institutional fear of resisting change
R	Conducts 20 person review with briefing after every project	1) Better daily log reports	1) Competitive industry prevents overhead cost of effective overtime study 2) Union would not accept overtime study 3) Labor halls limit the number of new workers by year
S	Weekly reports compares estimate to actual man hour and cost to percent complete	1) Information flow in the office 2) Productivity analysis for new equipment and tools 3) Document claims better	1) Other subs impacting electrical work 2) Cyclic nature of business 3) Demanding clients want time from firm's overhead

Table 2 (continued)

Firm	Q9 How Measure Reliability	Q6A Areas of Improvement	Q6B Barriers to Improvement
T	Track cost monthly, compare estimated to actual to cost to complete	1) Apprentice workers understand business operations 2) Cooperation among other trades at project	1) A/E & owner do not care about quality 2) A/E do not want to pay contractors for mistakes in plans and specs

Table 2 (continued)

Firm	Q7 Three Most Important Factors	ISSUE 1 Use of Computers	ISSUE 2 Use of Computer Estimating Program
A	1) Technically competent personnel 2) Management versed in interpersonal skills 3) Follow through-paperwork and daily chores	Yes	Yes
B	1) Taking care of details: project manager estimates, schedules, and builds individually	Yes	No
C	1) People training 2) Monitoring cost 3) Accept new ideas	Yes	Yes
D	1) Know true cost 2) Experience in knowing durations and cost	Yes	Yes
E	1) Quality of work 2) Office knowledge 3) Short reactions to change orders	No	No
F	1) Open communication 2) Flexibility of having own work force 3) Quality control	Yes	No
G	1) Good technical workers 2) Hard working employees 3) Supportive management that is encouraging	Yes	Yes

Table 2 (continued)

Firm	Q7 Three Most Important Factors	ISSUE 1 Use of Computers	ISSUE 2 Use of Computer Estimating Program
H	1) Fairness 2) Owner gets value 3) Complete a detailed cost estimate early	Yes	Yes
I	1) Provide quality 2) Commitment to long term profit not quick buck	Yes	Yes
J	1) Proper scheduling 2) Price control 3) Communication	Yes	Yes
K	1) Hard working employees 2) Gaining experience 3) Open minded to new ideas	Yes	Yes
L	1) Good estimates 2) Good tracking of projects 3) Retaining quality people	Yes	Yes
M	1) Good partnership 2) Small, controllable operation 3) Quality of work	No	No
N	1) Close review of plans and specs 2) Picking proper job niche	No	No
O	1) Schedule an early completion of a project 2) Coordination between subs and prime 3) Interpretation of documents	Yes	No

Table 2 (continued)

Firm	Q7 Three Most Important Factors	ISSUE 1 Use of Computers	ISSUE 2 Use of Computer Estimating Program
P	1) Dedication 2) Accuracy in bids and construction 3) Quality	Yes	No
Q	1) Satisfy owned 2) Proper relations with subs 3) Quality construction on time within budget	Yes	No
R	1) Quality estimates 2) Project manager properly breaks down project 3) following schedule and breakdown sections	Yes	Yes
S	1) Quality Product 2) Making a profit	Yes	Yes
T	1) Know actual cost in estimate 2) Professional conduct 3) Satisfy customers	Yes	Yes